REPRESENTATIONAL AND INFERENTIAL REQUIREMENTS FOR DIAGRAMMATIC REASONING IN THE ENTITY RE-IDENTIFICATION TASK[1]

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Diagrammatic reasoning is ubiquitous in Army reasoning: situation understanding and planning in the Army both involve representing aspects of the situation and plans in the form of diagrams. We have been developing a general architecture to support diagrammatic reasoning for Army applications, and in an earlier report [1] we discussed an application in simple maneuver recognition. Our research strategy has been to investigate a variety of applications, each bringing additional requirements for perception and diagrammatic object creating capabilities that can assist the army. One such area is the army's All Source Analysis System (ASAS) that is designed to automate the processing and analysis of intelligence data from all possible sources. One of its purposes is to keep track of various enemy assets, based on a variety of sensors and reports, including direct sightings of entities. In order to maintain a coherent view, the system has to decide whether a new sighting refers to a new entity, a previously known entity that has since moved (re-identification) or is erroneous. This is the *entity re-identification* task. We have a built a system that uses an abductive reasoning process together with a diagrammatic reasoning system to solve this problem. In this paper, we look at some of the issues that the entity re-identification task poses for diagrammatic reasoning.

When information in a set of premises is represented in a diagram, information that follows from the premises is often available in the same diagram to be picked up by perception, and often this additional information is called a *free ride*. A physical diagram (on a screen or on paper) is an image that contains diagrammatic objects – points, curves and regions – that represent objects of interest in the domain of discourse. Our diagram representation structure (DRS) is a data type that contains representations of the diagrammatic objects in the image. The objects in DRS have associated with them information about their spatiality -- locations for point objects, sets of points that constitute the objects for curves and regions. The DRS architecture to be discussed in this paper is an improved version of the one in [1].

There are two types of perception routines: the ones in the first type re-perform the figure-ground separation on the image – rather than on the DRS – perceiving what we call emergent objects (e.g., the two sub-regions that emerge when a curve intersects a region.) Routines of the second type perceive spatial properties of objects and spatial relations between objects. These routines work from DRS. DRS thus is an intermediate representation that supports reconstituting the image, needed for emergent object identification, and also the perceptual routines that perceive properties of and relations between objects. More information on the Diagrammatic Representation System and the accompanying perceptual routines can be

[1] The research was supported by participation in the Advanced Decision Architectures Collaborative Technology Alliance sponsored by the U.S. Army Research Laboratory under Cooperative Agreement DAAD19-01-2-0009.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 DEC 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	
Representational And Inferential Requirements For Diagrammatic Reasoning In The Entity Re-Identification Task	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Computer Science and Engineering Ohio State University**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2005 in Orlando, Florida. , The original document contains color images.

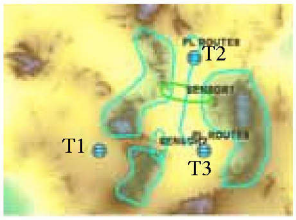
14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

found in references [1] and [2]. Another set of routines, called *action routines,* create diagrammatic objects that satisfy specific perceptual criteria, such as "a curve object that intersects a given region object," and "a point object inside the region object."



The diagram on the left can be used to illustrate certain subtasks that arise in an entity re-identification problem, and that are especially appropriate for diagrammatic reasoning. In order to decide if a newly sighted object in an entity in the data base, the system needs to come up with a set of possible paths from the entity's previously known location to the location of the new sighting. T1 and T2 are two tanks that are in the system. T3 is a tank that has been sighted at a later time. In order for T3 to be T1 (T2), at least one path should exist from T1 (T2) to T3. Path finding is complicated by the fact that the area of operations is over open terrain where the number of possible routes is often infinite. Thus, any path finding algorithm must be able to collapse these infinite number of paths into a set of paths where each member of the set is a representative of a class of paths. These paths, called *representative paths*, can then be subjected to further scrutiny, such as ensuring that the time taken to traverse the path is less than the time between reports and, if needed, modifying them to satisfy various spatial and temporal constraints. Another subtask involves detecting whether a path intersects a sensor field. If a path is found to intersect a sensor field, as in the figure above, and there is no corresponding sensor activity, the system has to try and modify this path to see if it can avoid the sensor field. The path that is so modified has the added constraint that it should remain within the same representative class. An interesting corollary to this is when there is a sensor report of activity, but the path generated by the system does not go over the sensor area. In this case, the system has to try and modify the path such that it does intersect with the sensor region while still satisfying the various constraints such as time to traverse and retaining its membership in the same representative class. There are two companion paper abstracts that are also being submitted for presentation at the conference: one on the fusion reasoning that uses abductive inference to solve the overall re-identification task [3], and the other [4] on the computational complexity of the large suite of perceptual and action routines that we are building for diagrammatic reasoning in general. In contrast to [4], the full paper will focus on the routines that are especially required for the entity re-identification task, how the task is represented in DRS, and the general DRS/Image architecture.

References

1. B. Chandrasekaran, John R. Josephson, Bonny Banerjee, Unmesh Kurup, and Robert Winkler, "Diagrammatic Reasoning In Support Of Situation Understanding And Planning," *Proceedings of Army Science Conference*, Dec 2-5, 2002, Orlando, FL.

2. B. Chandrasekaran, Unmesh Kurup, Bonny Banerjee, John R. Josephson and Robert Winkler, "An Architecture for Problem Solving with Diagrams," in *Diagrammatic Reasoning and Inference*, Lecture Notes in AI 2980, Berlin: Springer-Verlag, 2004, pp. 151-165.

3. J. R. Josephson and V. Bharathan, "An Abduction Engine for Entity Re-Identification and Tracking," abstract submitted to ASC-2004.

4. Bonny Banerjee and B. Chandrasekaran, "Perceptual and Action Routines in Diagrammatic Reasoning for Information Fusion," abstract submitted to ASC-2004.